



Passive control system using Triple Friction Pendulum in segmental building

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Abstract- Base isolation or seismic isolation enables the reduction in earthquake forces by lengthening the fundamental natural time period of structure; hence it is significantly effective in low and mid-rise buildings with less than 10 stories. Taller building with height more than 10 stories already have larger time period and the effectiveness of base isolation is reduced. In this paper an attempt has made to study the feasibility of sliding isolation at intermediate floor levels. R.C.C. 18 stories are analyzed by dividing each building into different segment and each segment is isolated with Triple Friction Pendulum isolators. The response of structure with isolators at multiple floor levels are studied with 1940 El Centro, 1979 Array#05 and 1989 Gilroy time-history and responses are compared to the conventional fixed base structure and with structures isolated at base and at intermediate floor level.

Keywords- Base Isolation, Triple Friction Pendulum, Segmental Building.

I. INTRODUCTION

Base isolation has been recognized as one of the effective passive control technique to decrease the earthquake forces. Base isolation is the technique which decouples the building or structure from the horizontal components of the ground motion by interposing the structural element with low horizontal stiffness between structure and foundation [1]. Base isolation is less effective in buildings which have lower natural time-period i.e. generally buildings with height less than 10 stories. Buildings with more than 10 stories or 15 stories already have contained the larger time period and not needed to be isolated and taller buildings are already flexible in nature and after application of base isolation flexibility increase much more, But in taller building there is enough deformation available which may lead to damage of structure and non-structure components of building, and therefore some technique must be used to control the structure. One technique may be concept of segmental building in which the building or structure is divided in different segment and each segment is isolated. In this paper attempt is made to investigate the feasibility of sliding isolation with triple friction pendulum at intermediate floor level. The 18 storey R.C.C. buildings are divided into different segment and isolated. Non-linear time history analysis is carried out for 1940 El Centro, 1979 Array#05 and Loma prieta 1989 Gilroy earthquake time history by using SAP 2000.

II. ANALYTICAL MODEL

RCC structures taken for this study are 18 stories high. Following cases are studied to investigate the dynamic behavior of sliding isolators at intermediate floor levels. (1) Fixed base structure (Case-I) (2) structure with all isolated at base (Case-II) (3) structure with isolators at three different levels, at base and two other levels of 1/3 height (Case-III).

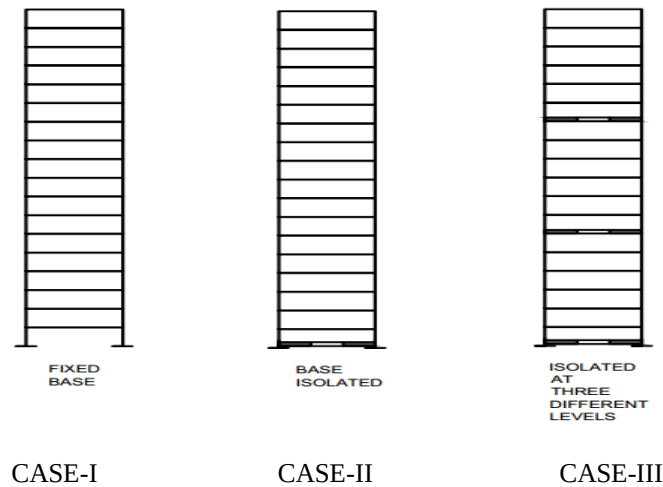


Fig. 1. Location of isolators for 18 stories building

III. DIMENSIONS AND PROPERTIES

A.18 Stories Building

Height of story	3m
Number of story in segment	6
Plan area	18mx18m
Total height of building	54 m
Size of Beams	0.45mX0.8m
Size of Column	0.6Mx0.6m

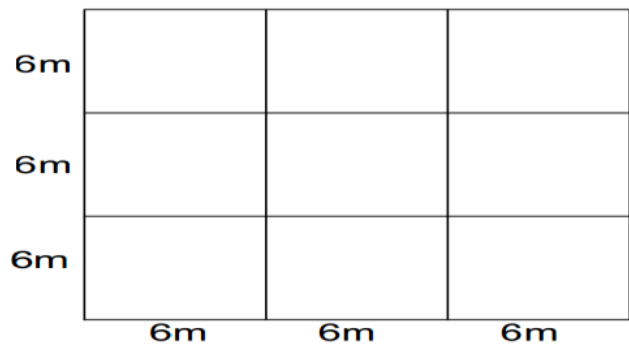


Fig. 2. Plan of 18 stories building

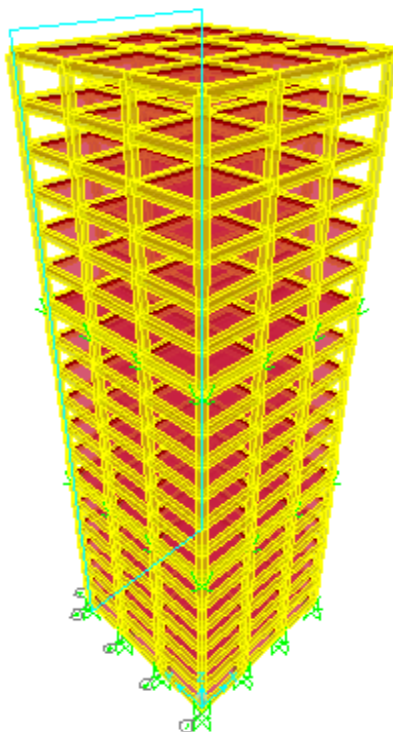


Fig. 3. 3D view of the SAP2000 model 18 Stories

IV. TIME HISTORY

Table 1. Different time history used in analysis

Time Histroy	Earthquake Magnnitude	Distance (km)	PGA (cm/sec2)
Imperial Valley, 1940,El Centro	6.9	10	452.3
Imperial Valley, 1979,Array#05	6.5	4.1	386.04
Loma Prieta, 1989,Gilroy	7.0	12	652.49

Source: SAC Steel Project | 1301 S. 46th Street | Richmond, CA 94804-4698 | <http://www.sacsteel.org/>

V. ANALATICAL RESULTS

After using non-linear time history in the SAP 2000, following results are obtained.

A. Natural Time Period

Natural time period of 18-storey structure for first three modes with three different cases are shown in fig.it is observed that the time period of Case-III is highest for all modes as compared to the other Cases. It is due to isolator provide in building segmental.

Table 2. Different modes in Natural Time period (sec) of 18-storey Structure

	CASE-I	CASE-II	CASE-III
Mode 1	1.744032	4.221164	5.318688
Mode 2	1.744032	4.221164	5.318465
Mode 3	1.412867	2.787748	4.24121

B. Storey Drifts

Considerable reduction in storey drift can be seen in structures isolated at multiple levels when compared to the structure isolated at base level. The maximum stories drift reduction with respect to fixed base structure in 18 stories is shown as 77.25% for Case-III in Loma Prieta time history. It is observed that when isolators are provided at multiple levels, there are considerable reductions in stories drift as compared to the fixed base structure as well as base isolated structures. The plots of stories drift for different cases and for different time history are shown in fig. 4 to fig. 6. Table 3 Shown the reduction in stories drift for different case.

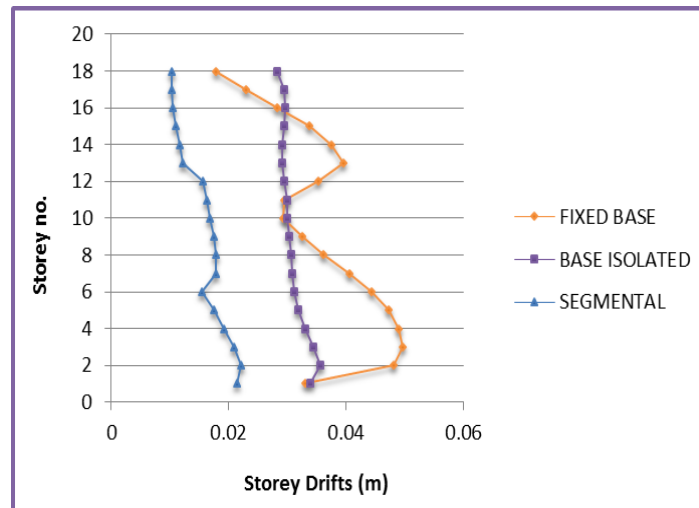


Fig. 4. Plot of storey drift for El Centro in 18 storey building

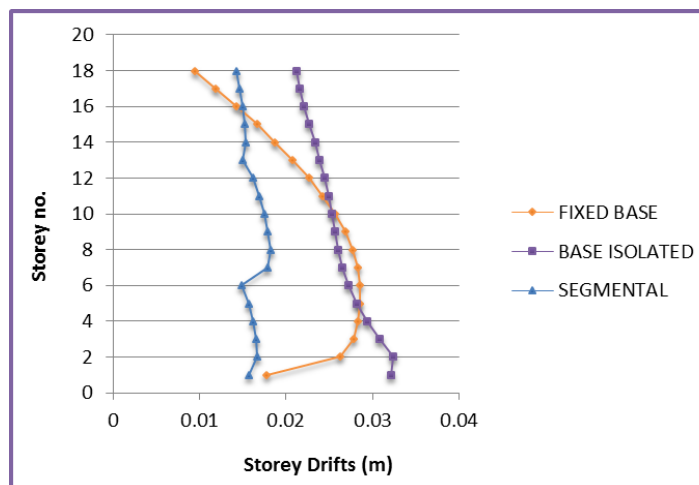


Fig. 5. Plot of storey drift for Array in 18 storey building

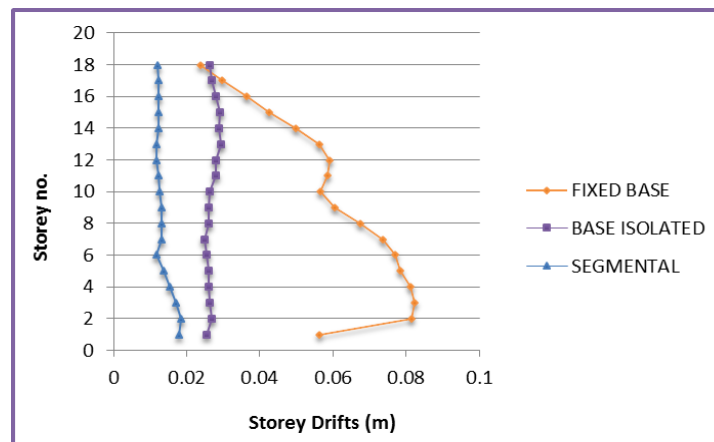


Fig. 6. Plot of storey drift for Loma Prieta in 18 storey building

Table 3. Reduction in Storey Drifts (%) w.r.t Case-I (Fixed Base)

	CASE-II (Base Isolated Building)	CASE-III (Segmental Building)
El Centro	14.99	56.54
Array#05	08.79	28.39
Loma Prieta	54.82	77.25

C. Acceleration

Acceleration of different cases are shown in fig.7 to fig.9 it is observed from the results that there are considerable reductions in acceleration as compared to the fixed base structure and structure isolated at base. The maximum reduction in acceleration in 18 storey structure as compared to fixed base is shown as 83.41% for Case-III in Loma Prieta time history. The tabular comparisons of reductions in acceleration for different cases are shown in table 4.

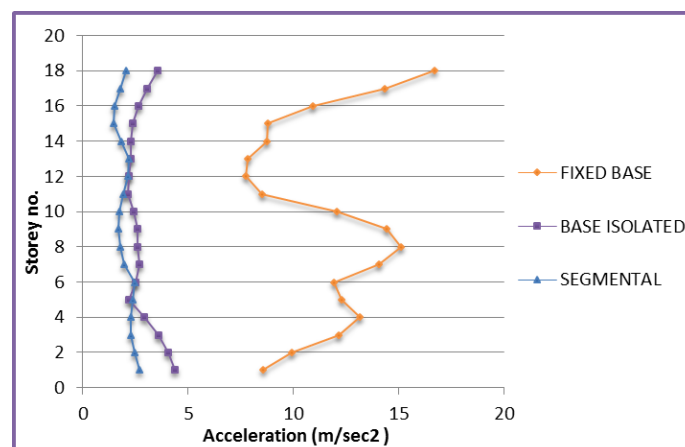


Fig. 7. Plot of Acceleration for El Centro in 18 storey building

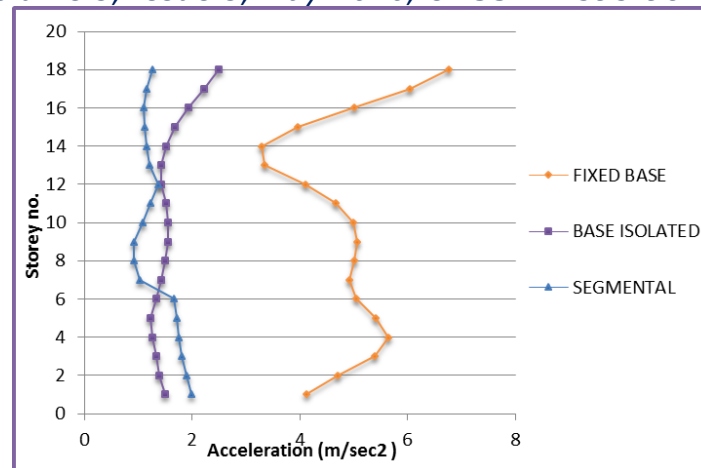


Fig. 8. Plot of Acceleration for Array in 18 storey building

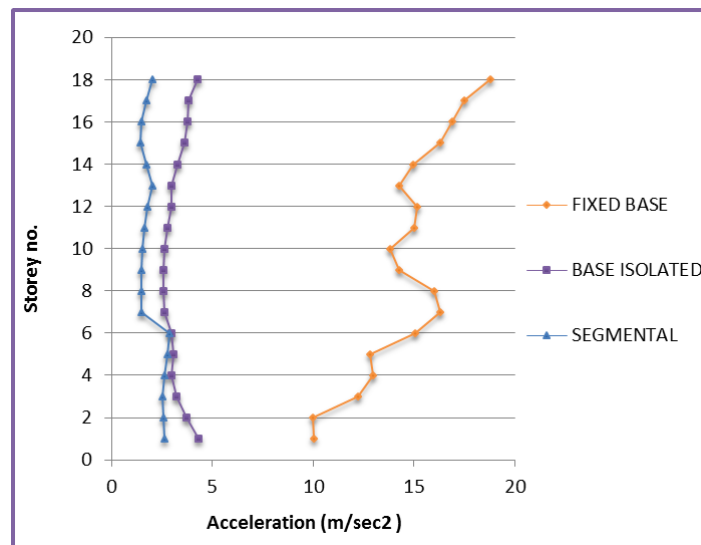


Fig. 9. Plot of Acceleration for Loma Prieta in 18 storey building

Table 4. Reduction in Acceleration (%) for 18-storey w.r.t. Case-I (Fixed base)

	CASE-II (Base Isolated Building)	CASE-III (Segmental Building)
El Centro	66.81	78.87
Array#05	64.80	69.07
Loma Prieta	75.23	83.41

D. Base Shear

The base shear charts for different cases are shown in fig.10 to fig.12 the maximum reduction in base shear for 18 storey structure as compared to the fixed base is observed as 89.07% for Case-III in Loma Prieta time history. Tabular comparison of reduction in maximum base shear as compared to the fixed base is shown in table 5.

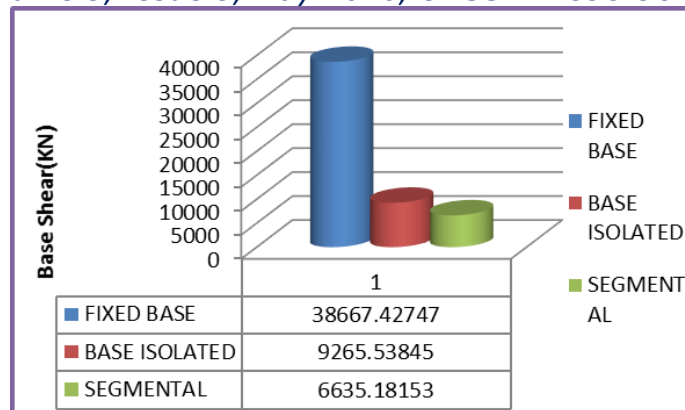


Fig. 10. Plot of Base shear for El Centro in 18 storey building

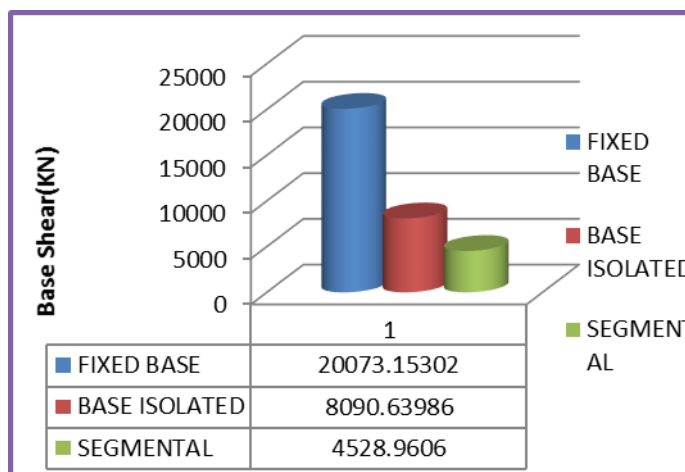


Fig. 11. Plot of Base shear for Array in 18 storey building

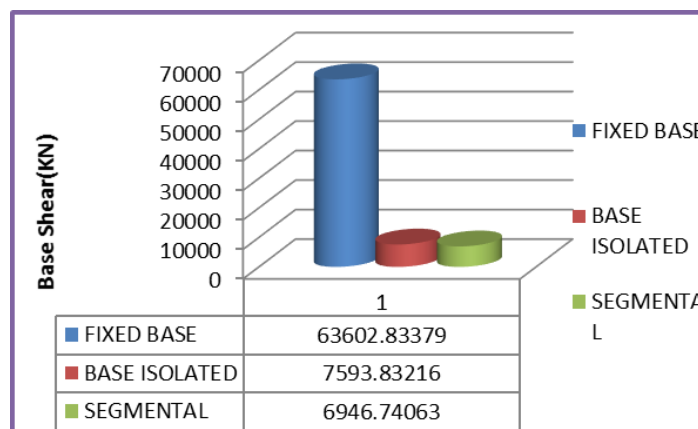


Fig. 12. Plot of Base shear for Loma Prieta in 18 storey building

Table 5. Reduction in Base Shear (%) for 18-storey w.r.t. Case-I (Fixed base).

	CASE-II (Base Isolated Building)	CASE-III (Segmental Building)
El Centro	76.03	82.84
Array#05	59.69	77.43
Loma Prieta	88.06	89.07

E. Over Turning Moment

The considerable reduction in Overturning Moment can be seen for structures isolated at multiple levels as compared to the fixed base as well as isolated at base. The maximum reduction in Overturning Moment for 18 storey structure as compared to fixed base structure is shown as 60.32% in Case-III for Loma Prieta time history ground motion. The fig.13 to fig.15 are shown the charts for Overturning Moment for different Cases. Tabular comparisons for different cases in reduction in Overturning Moment are shown in Table 6.

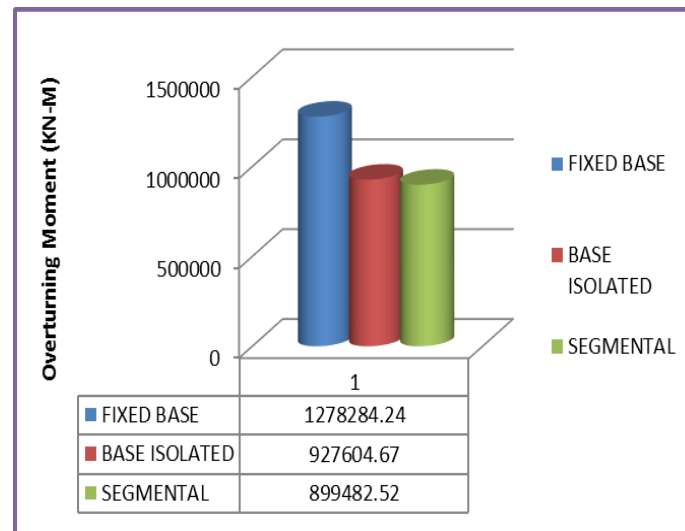


Fig. 13. Plot of Overturning Moment for El Centro in 18 storey building

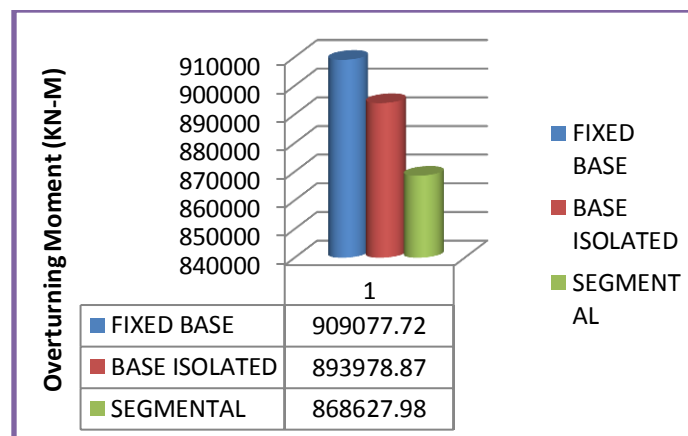


Fig. 14. Plot of Overturning Moment for Array in 18 storey building

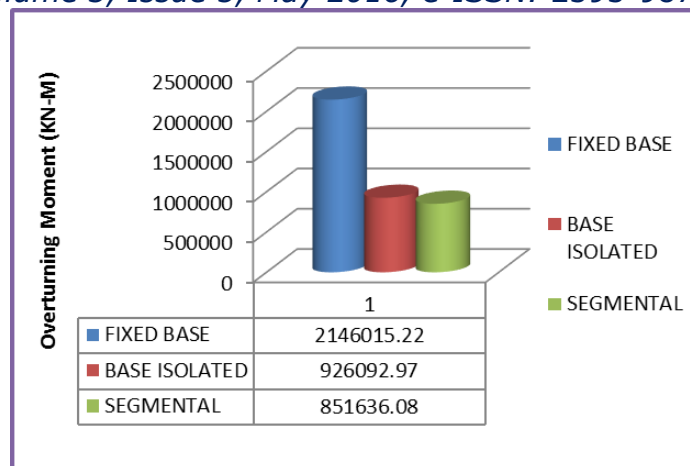


Fig. 15. Plot of Overturning Moment for Loma Prieta in 18 storey building

Table 6. Overturning Moment (%) for 12-storey w.r.t. Case-A (Fixed base)

	CASE-II (Base Isolated Building)	CASE-III (Segmental Building)
El Centro	27.43	29.63
Array#05	1.66	4.45
Loma Prieta	56.85	60.32

VI. CONCLUSION

From the above analytical study following observations are noted

A. Increase in fundamental time periods from 1.74 to 5.31 sec is observed in 18 storey in Case-III.

B. For the 18-Storey building, maximum reduction in storey drift was observed in Case-III. The average reduction was observed to be 77.25% as compared to Case-I (fixed base) and 49.65% reduction as compared to Case-II.(base isolated).

C. Maximum Reduction in base Shear was observed to be 89.07% in 18 storey respectively in Case-III as compared to fixed base system Case-I. Also the maximum reduction was observed to be 44.02% as compared to base isolated Case-II for 18 storey structure respectively.

D. Maximum Reduction in Acceleration is 83.41% in 18 storey respectively in Case-III as compared to fixed base system Case-I. Maximum reduction was observed to be of 36.12% as compared to base isolated Case-II for 18 storey structure.

E. Maximum Reduction in over-turning moment is about 60.32% for 18 storey structure respectively in Case-III as compared to fixed base structure.

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